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TRACTOR REPAIR. AGRICULTURAL MACHINERY--SERVICE OCCUPATIONS, MODULE NUMBER 16.

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THE PURPOSE OF THIS GUIDE IS TO HELP TEACHERS PREPARE POSTSECONDARY STUDENTS FOR THE AGRICULTURAL MACHINERY SERVICE OCCUPATIONS AS PARTS MEN, MECHANICS, MECHANIC'S HELPERS, AND SERVICE SUPERVISORS. IT WAS DESIGNED BY A NATIONAL TASK FORCE ON THE BASIS OF RESEARCH FROM STATE STUDIES. THE MAJOR OBJECTIVE IS TO DEVELOP (1) AN UNDERSTANDING OF THE PROCEDURES TO FOLLOW IN OVERHAULING A TRACTOR, AND (2) THE ABILITY TO DISASSEMBLE, REPAIR, REASSEMBLE, AND TUNE THE TRACTOR FOR FIELD OPERATING CONDITIONS. THE GUIDE INCLUDES SUGGESTIONS FOR ITS INTRODUCTION. SUBJECT-AREA UNITS COVER--(1) DIAGNOSING NEEDED TRACTOR REPAIRS, (2) PREPARING A TRACTOR ENGINE FOR REPAIR, (3) REPAIRING TRACTOR ENGINES, CLUTCHES, TRANSMISSIONS, BRAKES, AND STEERING UNITS, (4) REPAIRING AND ADJUSTING FINAL DRIVES AND DIFFERENTIALS, AND (5) PAINTING TRACTORS. EACH UNIT INCLUDES SUGGESTED SUBJECT-AREA CONTENT, TEACHING-LEARNING ACTIVITIES, INSTRUCTIONAL MATERIALS, AND REFERENCES. CRITERIA FOR EVALUATING OUTCOMES ARE LISTED. THE MODULE IS SCHEDULED FOR 168 HOURS OF CLASS INSTRUCTION, 366 HOURS OF LABORATORY EXPERIENCE, AND 250 HOURS OF OCCUPATIONAL EXPERIENCE. TEACHERS SHOULD HAVE EXPERIENCE WITH AGRICULTURAL MACHINERY. STUDENTS SHOULD HAVE MECHANICAL APTITUDE AND AN OCCUPATIONAL GOAL IN AGRICULTURAL MACHINERY. THIS DOCUMENT IS ALSO AVAILABLE FOR A LIMITED PERIOD AS PART OF A SET (VT 00 488 THROUGH VT 000 504) FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 980 KINNEAR ROAD, COLUMBUS, OHIO 43212, FOR $7.50 PER SET. (JM)

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TRACTOR REPAIR

One of Sixteen Modules in the Course Preparing for Entry in

AGRICULTURAL MACHINERY - SERVICE OCCUPATIONS

Module No. 16

The Center for Research and Leadership Development

in Vocational and Technical Education

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TRACTOR REPAIR

Major Teaching Objective

To develop (1) an understanding of the procedures to follow in overhauling a tractor and (2) the ability to disassemble, repair, reassemble, and tune the tractor for field operating conditions

Suggested Time Allotments

At school

Class instruction	168 hours	
Laboratory experience	336 hours	
Total at school		504 hours
Occupational experience		250 hours
Total for module		754 hours

Suggestions for Introducing the Module

The most important job responsibility of the agricultural machinery mechanic is repairing the tractor. To do this, he must understand the function of each part in the tractor and follow a systematic procedure. He must understand the various units on a tractor, their purpose, and the operation. Above all, he must be able to disassemble, diagnose troubles, make repairs, reassemble the unit, and get the tractor to function properly under field conditions.

Outlined in this module are the general steps or procedures to follow when making repairs common to all makes and models of tractors. For specific adjustments the manufacturer's specifications should be consulted and the adjustments made accordingly. If the repair procedure outlined in this module is not applicable to a tractor, follow the manufacturer's repair procedure.

Some classroom time should be devoted to discussion and study of each step in repair procedures, but the greatest part of the time should be allotted to student repair of tractors in the shop.

After each student has completely overhauled his first tractor, have him overhaul another tractor of the other kind (diesel or gasoline). With the second overhaul, he should develop sufficient understandings and abilities for a marketable skill in tractor repair.

Competencies to be Developed

I. To determine the extent of repair needed by a tractor

Teacher Preparation

Subject Matter Content

A tractor should be thoroughly tested to determine the extent of overhaul needed before any disassembly of the engine is begun. Tests provide valuable clues to possible internal malfunctions of the engine or other parts. As these tests are made record all observations.

1. Field tests. When operating the tractor under load observe the following:

   a. Oil pressure activity. A low pressure reading may indicate any of the following:

      1) Loose rod or main bearings
      2) Bad oil pump
      3) Loose camshaft bearing

   b. Blow-by through breather. Excessive blow-by means that the engine may have any of the following malfunctions:

      1) Worn rings
      2) Hole in piston
      3) No ring tension on cylinder wall
      4) Excessively high water temperature

   c. Operating water temperature. High operating water temperature suggests:

      1) Bad thermostat
      2) Plugged radiator fins or internal tubes
      3) Blown head gasket allowing compression vapors to escape into the engine coolant
      4) Internal crack in engine block or head

   d. Excessive noise or knock. Excessive noise in an operating engine suggests:

      1) Loose rod bearings, which knock when the engine is free running.
      2) Loose main bearings, which knock under load.
      3) Poor detination timing

e. Excessive blue or black smoke coming from the exhaust pipe. A black smoke indicates that the fuel mixture is too rich with fuel. This problem can be eliminated by tuning up the fuel system. A blue smoke indicates that oil is getting by the rings into the cylinder and burning with the fuel. Excessive blue smoke coming from the exhaust pipe suggest:

   1) Worn or plugged oil rings
   2) Fouled valve guide, which causes the engine to smoke after long periods of idling

2. Laboratory test. The best method of testing a tractor engine and clutch in the laboratory is by using a dynomometer. All findings should be recorded on the dynomometer test sheet.

3. Compression test. A compression test reveals malfunctions in the compression chambers of the engine and their associated parts. The following procedures should be followed when making a compression test on a gasoline or a diesel engine.

Gasoline engine compression test

a. Remove all spark plugs.

b. Insert compression gauge in the spark plug openings.

c. Crank engine, turning it over five times.

d. Read the compression gauge, noting the compression developed in each cylinder. All cylinders develop a compression within 10 pounds per square inch of each other and within the manufacturer's specifications.

e. Put oil in cylinders to determine whether the low compression is caused by valves or rings.

   1) The oil seals up bad rings and compression readings increase.
   2) If two adjacent cylinders have low compression, insert spark plug in one and check the other cylinders with the compression gauge. An increase in compression indicates a blown head gasket between cylinders.

Diesel engine compression test

a. Remove fuel line from the number die injector.

b. Remove attachment nuts on injector and then the injector.

1) When removing the injector, use a crowfoot bar to pry injector out of the head. Be extremely cautious not to damage the nozzle end of the injector. If the nozzle end is bumped, the small orfices in the tip will close.
2) Wrap the injector in a soft cloth to protect it while it is out of the engine.

c. Insert compression gauge of suitable capacity for a maximum compression of 1000 p.s.i. The reading should be about 500 p.s.i.

d. Start engine and let idle at the speed recommended by the manufacturer and read the gauge. Compare reading with the specifications set up by the manufacturer.

e. Install the injector, reversing the order outlined in the procedure above.

f. Using the procedure outlined above, test the compression in all cylinders.

g. Check the running heat efficiency of the engine under load.

This check is made by placing heat chalk on the exhaust opening on each cylinder. The chalk turns color if the cylinder is operating with proper heat efficiency. The injector and valves must function properly and proper compression must develop in the cylinder in order to get a proper color reading. Color reading guides are available in most diesel repair shops.

4. Visual inspection. The following observations should be made and noted when testing the tractor in the field and in the laboratory:

a. External oil leaks

b. Broken parts

c. Loose bolts

Suggested Teaching-Learning Activities

1. Have students observe several diesel and gasoline tractors needing overhauling, in operation in the field.

Vary the amount of load that these tractors operate under, and have the class observe what happened and record their observations. At this time discuss with them the possible repairs needed.

2. Bring these tractors into the school laboratory and have students run a compression test on them and test them with a dynamometer. Have students record their findings.

Note. For best results, have enough tractors so that only two students are working on a tractor. Assign students to tractors to be tested, and require them to stay with these tractors until they are completely overhauled.

Suggested Instructional Materials and References

Instructional materials

1. Dynamometer
2. Compression gauge
3. Spark plug wrench
4. Crowfoot bar
5. Heat chalk

References

1. Manufacturer's service manuals

Suggested Occupational Experience

Have students run field, laboratory, and compression tests on machines considered for overhaul at a local agricultural machinery dealership. Have them diagnose the malfunctions in the tractors and suggest repairs.

II. To prepare a tractor engine for repair

Teacher Preparation

Subject Matter Content

Thorough cleaning is the first step in preparing an engine for verhaul. The best method is steam cleaning; but if this is

not possible, clean the engine with a mixture of one part "Gunk" concentrate (a cleaning compound made for dirty engines) with four parts kerosene. Paint the engine with this mixture and allow it to soak for 20 minutes; then wash it off with a spray of water.

After the engine has been thoroughly cleaned, follow these steps to prepare it for overhaul:

1. Remove engine accessories. These include the hood, shrouds, radiator shell and grill.

2. Drain the coolant from radiator and block into a clean container and inspect it for rust particles and other foreign particles.

3. Remove all radiator clamps and hoses, noting those that need to be replaced. Record this information on the reconditioning sheet.

4. Remove the radiator holding bolts and the radiator.

    a. Check the radiator for bent fins, external leakage, and corrosion build up inside the radiator.

    b. If the radiator needs repair, send it to a radiator shop.

5. Remove external engine parts.

    a. Battery clamp and battery

        1) Remove battery cables removing the ground cable first.
        2) Inspect cables and note condition.
        3) Using a hygnometer and voltmeter, test the battery and recharge it, if necessary.

    b. Starter

    c. Water mainfold and thermostat

        1) Check thermostat and note its condition

    d. Carburetor (gasoline engine only)

        1) Remove linkage.
        2) Turn valve on gas tank off and remove gas line.
        3) Remove air cleaner base and note its condition.

e. Governor.

Diesel engines do not have the same type of governor as gasoline engines. Omit this step on the diesel engine.

1) Disconnect linkage and oil line.
2) Remove bolts around the housing.
3) Slip governor unit from housing.
4) Check spring for tension.

f. Intake and exhaust mainfold

g. Air cleaner

1) Check condition of air cleaner. An excessively dirty cleaner may suggest possible clues to causes of internal malfunctions.

h. Spark wires, spark plugs, and distributor

A diesel engine has a different type of fuel and ignition system. The following procedures should be followed when removing the injector and injector pump:

1. Injector

a. Turn fuel valve off at tank.

b. Remove fuel lines from injectors.

1) All fuel lines from pump to injectors must be removed at each end.
2) Remove line bracket.
3) Be careful not to bend lines.

c. Remove injector.

1) Remove hold-down nuts.
2) Use crowfoot bar to pry injector out.
3) Remove injector, being careful not to bump the nozzle tips.
4) Wrap injector in a soft cloth to avoid damage to the nozzle tips while they are out of the engine. Always remove the injector before removing the head.

2. Injection pump

a. Locate marks used in timing pump.

b. Rotate engine until marks are in proper position and the number one cylinder is on the compression stroke.

c. Remove throttle and stop linkage attached to pump.

d. Remove fuel lines.

e. Remove primary fuel line from pump.

f. Remove bolts holding the pump to the block.

g. Remove oil line that runs from the pump to block.

h. Remove pump.

i. Any calibration of the pump must be made on a test stand. Most dealers do not do this job but send pumps to special diesel repair shops. Some pumps, however, may be calibrated on the engine, operating at maximum load and using a ball fuel meter or dynamometer to measure fuel consumption.

j. Three types of injection pumps have been developed for use on diesel engines.

   1) Roasa master
   2) Boash
   3) Simms

   Manufacturer's specifications should be followed when overhauling these pumps.

k. Clean injection pump screen which is located on head of pump.

   1) Remove plug.
   2) Remove screen and "o" ring.
   3) Wash in solvent and blow dry with compression.
   4) Install screen on plug and ring.
   5) Install injection pump in head.

<u>Suggested Teaching-Learning Activities</u>

1. Demonstrate the cleaning and disassembly procedures outlined in the subject matter content. Emphasize proper procedures and tool usage.

2. Have students thoroughly clean their assigned tractors and remove all accessories.

3. Have students remove the external engine parts on their tractors according to the procedures outlined in the subject matter content above.

Suggested Instructional Materials and References

Instructional materials

1. Tractor for student use
2. Complete tool kits
3. Demonstration tractor
4. Steam cleaner

References

1. Manufacturer's service manuals
2. Steam cleaner instructions

Suggested Occupational Experiences

1. Have students do the following at a local agricultural machinery dealership:
   a. Steam clean a tractor.
   b. Remove all tractor accessories.
   c. Remove all tractor external parts.

III. To repair a tractor engine

Teacher Preparation

Subject Matter Content

After thorough testing and removal of all accessories and external parts, the engine is ready to be overhauled. A mechanic should learn well the following procedure, which outlines a complete engine overhaul, before he accepts employment and proceeds to overhaul a tractor engine in an agricultural machinery dealership.

Disassemble the engine in the following manner, and make observations of worn parts, and other faults.

1. Valve cover

   a. Remove valve cover by taking out four attachment bolts. Make sure that the area around the cover is clean and dirt free before the cover is removed.

2. Rocker arm assembly

   a. Oil must flow to the rocker arm assembly through an oil line or stud which retains this assembly. Locate the flow openings and check to see if they are plugged.

   b. Remove the oil line.

3. Push rods

4. Head nuts or capscrews

   These are special nuts or capscrews of high strength steel. Under no circumstances should nuts or capscrews of any other material be used for this purpose.

5. Remove head

   a. Visually inspect the head, noting the following:

      1) Condition of valves
      2) Condition of headgasket
      3) Condition of top of piston

         a) Excessive carbon indicates bad rings.
         b) Piston loose in cylinder

      4) Pitting in the piston top and cylinder wall

         Pitting is caused by water entering the combustion chamber through the head gasket or a crack in the head or sleeve.

5) Taper of the cylinder wall

The taper of the cylinder is checked by a dial indicator or inside micrometer. Measure the diameter of the cylinder where the top ring travels and above the piston when at bottom dead center. By subtracting the latter measurement from the former the amount of taper can be determined. Compare the taper with maximum taper given in the manufacturer's specifications for the tractor.

6) Check cylinder for being out of round.

To check a cylinder for being "out of round," use the same tools as those used to check taper.

6. Remove valves from head and determine condition.

a. Place head on work lead.

b. Using suitable valve compressor, compress spring and cap and remove the two locks located on the end of the valve stem.

c. Release valve compressor.

d. Remove spring and valve cap. Some engines may have rotating valve caps on the exhaust valves. These caps allow valves to rotate, thus keeping the seat clean and free of carbon. Also, some engines may be equipped with two valve springs on each valve, allowing more positive valve seating.

e. Remove valves.

1) Visually inspect each valve for excessive burning.
2) Check valve stem for sticking in the guide, which is caused by carbon in the guide. The guide should be cleaned or replaced.
3) Check the valve seat for burning or cracks.

At this point in the overhaul procedure, study all observations made to determine whether a complete overhaul is necessary or whether reconditioning of the valves would bring the compression back to within manufacturer's recommendations. If the tractor needs a complete overhaul, follow these procedures:

1. Remove the engine block from the tractor mounting.

   a. Drain oil from the oil pan by removing the plug in the bottom of the pan.

   b. If necessary, remove the front axle and axle support, which is bolted to the engine block.

      1) Disconnect the front axle wishbone supports and steering linkage.
      2) Place safety jack under the transmission to support the engine while removing the front axle and wheels.
      3) Remove bolts around the rear engine bell housing. Usually there are one or two line-up pins in the rear bell housing which often stick and need to be freed by prying the engine away from the transmission.

   c. Attach engine lifting straps to the block so that when the engine is lifted from the mountings it will be balanced. Use short cap screws to replace the head studs or capscrews.

   d. Hook sound chain falls on hydraulic lifting crane to engine strap and remove the engine block from its mountings.

2. Place engine on an engine stand and fasten it down tightly. If an engine stand is not available, lay the engine block on its side on a workbench.

3. Remove oil pan.

   Take off capscrews around the oil pan, and check it for sludge deposits in the bottom.

4. Remove oil pump.

   a. Remove oil pump screen and pick-up tube. In some cases this tube may be a part of the pump.

   b. Remove locks on safety wire from the capscrews or nuts which hold the oil pump in place.

   c. Turn the pump housing back and forth until it comes free.

5. Remove fly wheel.

   a. Remove pressure plate.

      1) Remove capscrews on the pressure plate evenly.
      2) Be prepared to catch the pressure plate and clutch disk, as they drop when the last capscrew is removed.

   b. Remove flywheel nut locks and nuts.

      1) It may be necessary to lay a 2" x 4" block of wood, 12" long, beside the crankshaft to keep the crankshaft from turning during removal of flywheel nuts.
      2) Tap flywheel off with a soft mallet hammer.
      3) Because of the weight of the flywheel, be careful not to drop it while removing from the engine.

6. Check the flywheel starter ring gear for missing teeth and slippage on the flywheel, and record findings.

   a. Remove ring gear from the flywheel, cutting halfway through the ring gear with a cutting torch and splitting the remainder with a chisel, or cutting halfway through with a 1/4" drill and splitting the remainder with a chisel.

      Be extremely cautious to avoid cutting with the torch or drilling into the flywheel.

   b. Install new ring gear.

      1) Lay ring gear on flat fire bricks that completely support it.
      2) Use a torch to heat ring gear to 360° or until it turns a dark straw color.
      3) Quickly place ring gear on flywheel and let cool into place.

7. Remove pistons.

   a. On engines with sleeves, install a short capscrew and large washer at the top of each sleeve to hold sleeve while removing piston.

b. Cut ridge frame cylinder with a suitable ridge removing tool. Follow manufacturer's instructions for using the tool to remove the cylinder ridge.

c. Rotate crankshaft until the number one piston is at the bottom of its stroke.

d. Remove lock nuts on cotter pins from connecting rod.

e. Mark rod cap with a center punch on both halves to make certain it is reinstalled in the same position it was before disassembly. Also, notice whether mark is on the crankshaft side, and record observation.

f. Remove connecting rod nuts.

g. Remove rod cap.

1) Inspect insert for excessive wear, pitting, and corrosion.
2) Remove upper insert bearing.

h. Push piston out of cylinder.

i. Throw inserts away and reinstall cap on rod.

j. Repeat steps a through i to remove the remaining pistons.

8. Inspect pistons, pins, and connecting rods.

a. Clean piston.

1) Remove oil rings.
2) Remove carbon from the piston top with a scraper.
3) Remove carbon from ring bands with a broken ring.
4) Do not use a wire brush for cleaning these parts.
5) Clean oil groove and oil return holes. The oil return holes should be cleaned with a drill bit of the same size as the oil return holes so as not to enlarge the holes.
6) Using a micrometer, check the size of the pistons against manufacturer's specifications, and determine whether they are within limits. A micrometer check also reveals whether the pistons are standard or oversized.

7) Compare ring band of piston with that of a new ring and check it with a feeler gauge. Insert ring in groove. Check the distance between the ring edge and groove wall. Check size of gap with manufacturer's specifications for maximum allowance clearance. These measurements, along with visual inspection and piston size, indicate whether the piston should be replaced.

b. Inspect connecting rod.

Put the connecting rod cap in place on the rod with punch marks lined up and rod nuts torqued to manufacturer's specifications. Using an inside micrometer, check whether the inside of the rod is out-of-round and the connecting rod opening is within manufacturer's specifications. If the measurements are not within specifications, install a new rod or recondition the old rod at a machine shop.

c. Check wrist pin.

1) Remove wrist pin from rod.

a) Mark piston and rod with a center punch to make sure they are reinstalled in the same position they were before dissassembley.
b) Remove snap rings on lock bolts that retain pin in the piston.
c) Using a brass punch, drive the pin out of the rod. Some pistons require that the wrist pin be pressed out. This is a job for a machinist who has a special piston holder and press.

2) Using a micrometer, check pin to see whether it is within manufacturer's specifications.
3) Check inside of the rod bushing with a telescopic gauge and outside micrometer to determine whether the opening is within manufacturer's specifications.
4) Record all measurements in order to determine what parts should be replaced or reconditioned.

9. Check cylinder for taper and being out-of-round.

   These checks are made with an inside micrometer or dial indicator. If the taper is not within specifications or the cylinder is out-of-round, install new sleeves or rebore the cylinders.

10. Remove crankshaft.

    a. Before removing crankshaft, check end play. One bearing, usually the center or rear bearing, controls the end play with a thrust ring built on the insert or a spearate ring. Locate the thrust bearing, and pry crankshaft forward. Insert feeler gauge in the opposite side and measure the gap. Record the gap and check it against manufacturer's specifications. If a new bearing is needed, it may be obtained in oversize thrust to take up for wear on the crankshaft flange.

    b. Remove front crankshaft pulley.

       1) Remove set screw, nut, or retaining bolt from the pulley.
       2) Using a suitable puller, remove crankshaft pulley.
       3) Be careful to fit puller jaws on the solid part of the pulley.
       4) Check pulley for cracks and excessive wear on the sealed surface.

    c. Remove timing cover.

       1) Remove all cap screws and nuts on the retaining cover.
       2) Pry cover off.
       3) Notice if the crankshaft end-play adjusting setscrew is built into the retaining cover.

    d. Check backlash between camshaft and crankshaft gear with dial indicator.

       1) Mount dial indicator on front of engine with needle resting on camshaft gear teeth.
       2) Rotate camshaft back and forth without moving the crankshaft. Take dial reading and compare with manufacturer's specifications listed as camshaft gear backlash. If backlash is excessive, new gears are needed.

e. Check timing marks on the camshaft and crankshaft gears. The marks must line up before disassembly and at reinstallation.

f. Mark main bearing cap in relation to block. Be careful to put caps back in the same position and place when reinstalling them.

g. Remove main bearing capscrew or nuts. Some nuts or capscrews have locks, and others are self-locking.

h. Remove main bearing cap by tapping it with a soft mallet hammer. Inspect the insert bearing for pitting, grooving, and excessive wear. At this point it may be necessary to remove the rear main oil seal retainer and seal.

i. Remove crankshaft. Try to keep it standing on end to avoid possible warping.

j. Reinstall main caps on block and tighten them to prevent damage to the caps.

11. Check the crankshaft.

a. Using a micrometer, check each journal for the following:

1) Out-of-round condition
2) Excessive wear
3) Taper of journal

Micrometer readings should be recorded and compared with manufacturer's specifications.

b. Check rear oil seal surface.

c. Check straightness of crankshaft.

1) Using two "V" blocks, rest the number one journal on one block and the rear main journal on the other block.
2) Set dial indicator needle to ride against the center main bearing and rotate shaft. Record the dial reading. If the reading is excessively high, a new crankshaft or regrinding of the old one, is needed. Compare the dial readings with the manufacturer's specifications to determine whether to replace, regrind, or reuse the crankshaft.

12. Remove cylinder sleeves.

    a. Use a suitable puller to pull sleeves out of the block. Sometimes wet sleeves may be driven out of the block with a hard wood block.

    b. Remove the capscrews that hold the sleeve in place. If the engine does not have sleeves, have the cylinder rebored at a local machine shop.

13. Remove camshaft.

    a. Remove retaining bolts behind cam gear.

    b. Slip camshaft out of the block . It is not necessary to remove the gear from the camshaft unless the gear needs replacing, in which case it must be done in a press.

    c. Be careful not to let the camshaft lobes scrape on the cam bushing when slipping it out of the block.

    d. Check camshaft with a micrometer to determine the bearing journal and lobe sizes, and compare these measurements with the manufacturer's specifications.

14. Remove valve lifters and check them for excessive wear and pits in the flat surfaces.

15. Remove camshaft bushing.

    a. Use a suitable driver plug fitted to the cam bushing and drive out all bushings.

    b. Camshaft bushings, the heart of good oil pressure, should be replaced on all overhauls.

16. Clean engine block.

    a. Soak block in cleaner tank and wash with hot water.

       Blow out all oil passages with air. If steam cleaner is available, steam the block and force steam through the oil passages.

    b. The block should be cleaned after the cylinders have been rebored.

c. Using 80 grit sandpaper, sand the top of the block and the base where the sleeves are installed. Caution: the cylinder must be clean around the top flange and at the bottom where the "O" rings seal.

d. Check block for cracks.

Up to this point in the overhaul procedure, disassembly of the engine and inspection of its parts, has been emphasized. The emphasis now turns to the installation of new parts and reassembly of the engine. The following procedure should be followed in reassembling the engine and installing parts:

1. Install camshaft bushings.

   a. Coat the surface of the bushings with light number 10 oil and install them in the block with a driving plug.

   b. Make sure that the oil holes in the bushing align with the oil holes in the block.

2. Install cylinder sleeves.

   a. Before installing "O" rings on the sleeve or in the block, try each sleeve in the block to make sure it falls into place without having to be forced.

   b. Install "O" rings on sleeve or in the block, using the lubricant recommended by the manufacturer.

   c. Push sleeve into place with hand or a light tap of a soft mallet hammer.

   d. Check protrusion of sleeve above block to make sure that it comes within the manufacturer's specifications. Shims may be added under sleeve flange to increase the protrusion.

3. Coat valve lifters with number 30-weight oil and install them in the block.

4. Install camshaft.

   a. Coat bearings with number 30-weight oil.

   b. Slide the camshaft through each bearing. Do not let lobes slide on the bushings.

c. Check for free rotation of the camshaft. If it does not rotate freely, the bushings have been improperly installed.

d. Install camshaft retaining bolts, and check end play of shaft with dial indicator to compare with manufacturer's specifications.

5. Install crankshaft.

a. Remove main cap.

b. Install new bearing inserts in the block and cap. Make certain that the two bearing halves are installed opposite each other.

c. Coat bearing with 30-weight oil.

d. It may be necessary to install one-half of the rear main oil seal.

1) Coat back of seal with aviation sealer.
2) Soak inside with 30-weight oil.
3) Push into channel.

e. Place crankshaft in the block. Make certain that the camshaft and crankshaft gear timing marks are in line.

f. Install main bearing caps.

1) Place plastic gauge strip on the bearing and install the cap.
2) Align marks on caps with marks on the block.
3) Install main bearing bolts and locks.
4) Torque bolts down, 20 pounds at a time, to manufacturer's specifications.
5) Remove cap and read plastic gauge on the bearing. This indicates the bearing clearance. If too much clearance is read, oversized bearings are needed.

g. Check crankshaft end-play.

6. Install front timing cover.

a. Install front crankshaft seal in cover.

1) Coat outside of seal with aviation sealer.
2) Coat inside with number 30-weight oil.
3) Tighten all bolts uniformly.

7. Install crankshaft pulley.

   a. Coat pulley seal surface with 30-weight oil.

   b. Make sure inside of pulley is clean. If it is not, use sandpaper to clean and clear it.

   c. Use a block of wood and hammer to tap the pulley into the crankshaft and install retainer.

8. Install pistons on connecting rod.

   a. Read manufacturer's instructions for installing rings.

   b. Check rings for size.

      1) Insert rings in cylinder and measure end gap with feeler gauge. All rings except the oil rings, must be checked.
      2) Check manufacturer's specifications to be within clearance limits. If ring end clearance is inadequate, it should be filed.

   c. Check piston cylinder clearance.

      Insert piston into cylinder and check side clearance to be within manufacturer's specifications.

   d. Assemble connecting rod and piston.

      1) Have the pin and bushing fitted at a machine shop that has honing and aligning equipment.
      2) Install piston and rod together, making sure the mark on top of the piston is toward the front of the engine and the mark on the rod is in proper relation to the camshaft.
      3) Install locks on pins.
      4) Caution: follow manufacturer's guide for locating piston to rod alignment.

9. Install piston and connecting rod in the sleeve.

   a. Install rings on the piston with a recommended ring expander.

      1) Carefully place each ring on the piston with the top marking up.
      2) Make sure rings are in the right grooves.
      3) Follow ring manufacturer's specifications for installing rings on piston.

         Example: a) Oil ring should be installed in the bottom groove with the bevel toward the top.
         b) The scrapper ring must be installed in the second groove with the outside notch down.
         c) The compression ring must be installed in the top piston groove with the inside notch up.

   b. Remove rod cap.

   c. Cover piston and rings with number 30-weight oil.

   d. Place ring compressor around piston and compress rings. Note: Follow the manufacturer's specifications for the type of compressing tool to use.

   e. Slide skirt of piston into sleeve, making sure the notch or arrow is toward the front of the block.

   f. Tap piston into sleeve with hammer handle. Only light pressure is needed to force the piston out of the ring compressor. Make sure the connecting rod aligns with the crankshaft as the piston is tapped into the cylinder. Be careful not to scratch the crankshaft journals.

   g. Install rod bearing and check.

      1) Coat the upper half of the bearing insert with 30-weight oil and insert in the connecting rod.
      2) Push connecting rod with piston attached down onto crankshaft.
      3) Install lower half of bearing insert into the cap and cover with oil.
      4) Place a strip of plastic gauze on the insert in the cap.

5) Install cap on connecting rod.
6) Tighten rod bolts or nuts according to manufacturer's specifications.
7) Remove rod bolts or nuts and read the plastic gauge. Compare these clearance readings with the manufacturer's specifications. If the clearance is greater than those prescribed by the manufacturer, use oversized bearings and repeat steps five and six.
8) Install lock nuts and bend metal locks around nuts.
9) This procedure should be used when installing all rod bearings.

10. Overhaul and install the oil pump.

a. Disassemble oil pump.

1) Remove gear from pump, using suitable puller.
2) Remove all parts from pump and clean them thoroughly.
3) One should install an oil pump overhaul kit, which includes new gears, shaft, gasket, and pressure regulating valve, when overhauling an oil pump.
4) Install new pump parts.

a) Check backlash between gears.
b) Check gear-to-housing clearance.
c) Check gear end clearance.
d) Compare these findings with manufacturer's specifications. If the readings are higher than those set down in the manufacturer's specifications, replace the housing.

5) Install pump into the block, torque bolts to manufacturer's specifications, and lock with wire or metal locks.
6) Fill oil pump inlet tube with number 30-weight oil to aid in priming the pump.

11. Install oil pan.

a. Coat block with aviation sealer and stick gasket to it.

b. Install pan and tighten bolts. Do not tighten bolts too tight, as they will break the gasket.

12. Recondition cylinder head.

a. Clean head.

1) Using a 1/4 hp. drill with a wire brush, remove carbon from the head.
2) Use a carbon scraper to remove excess carbon that cannot be removed with a wire buffer.
3) Clean around valve seats.
4) Wash the head in a cleaning solution and then hot water.

b. Remove and replace valve guides.

1) Drive guides out of head with a suitable guide driver and hammer.
2) Using emery paper, clean hole in head where guides are inserted.
3) Wipe guides and blow area around guide holes clean with compressed air.
4) Coat guide with number 10-weight oil and drive in place with driver and hammer.
5) Follow manufacturer's specifications for length of guide protrusion.

c. Grind valve seats.

1) Select valve guide pilot to fit guide.
2) Select a stone to fit the valve seat outside diameter and the degree of angle on the seat.
3) Set grinder on the seat and reface the seat.

a) Make sure the seat is within allowable limits for width of seat.
b) If the seat is too wide, use a 15° and 75° stone to narrow the seat.

d. Using a straight edge, check the head for warp.

e. Reface valves.

1) Clean valves with wire brush.
2) Using a micrometer, measure the valve stem for comparison with the manufacturer's specifications.
3) Set valve grinding machine for proper valve face angle.

4) Reface all valves.

Check valve head thickness after grinding to be certain is is within manufacturer's specifications.

5) Resurface valve stems on grinding machine.
6) Place valve in the head and check margin of seat on valve face with bluing. Grind seat to bring it within manufacturer's specifications, and allow proper valve seating.
7) Check valve springs.

a) Using a valve spring tester, check spring length and the tension at a given length.
b) Compare these measurements with the manufacturer's specifications and replace valve springs not within manufacturer's limits.

8) Coat valves and stems with number 30-weight oil and place in the head.
9) Install valve spring and keeper.

a) Check valve spring to see if there is any difference in the top and bottom by checking for coils being close together.
b) Install valve seals on stem of valve if recommended by the manufacturer.

f. Clean and check energy cells.

Note: Some diesel engines use what is called an "energy cell" or "precombustion chamber" to increase combustion efficiency.

1) Remove cell from head.

a) Remove bolts from cell.
b) Remove bolts from cell hold-down bars.
c) Remove bars and caps.
d) Remove cell with the necessary special puller and slide hammer, and check for burnt tips and enlarged hole. Keep all cells and caps together.
e) Soak cell in carbon remover, wash, and blow dry with compressed air.
f) Lab the cap and cell on a special lapping tool.

g) Clean hole in head and check for burnt places where cell may leak. If the cell has been leaking, replace the compression.
h) Replace any burnt cell.
i) Assemble and install in reverse order, following the procedure outlined by the manufacturer.
j) Torque nuts and hold-down bar to manufacturer's specifications.

13. Install head on block.

a. Install a new head gasket.

b. Coat gasket with a recommended gasket sealer.

c. Install all head bolts and snug them down.

d. Use torque wrench to finish tightening head bolts. Follow manufacturer's sequence for torquing head bolts.

14. Install push rods.

Make certain that each rod is set in the valve-lifter socket.

15. Recondition rocker arm assembly.

a. Remove all arms from shaft.

1) Remove cotter pin and washer.
2) Note where oil holes are in respect to the shaft.

b. Resurface all rocker arms on valve refacing machine.

c. Check rocker arm shaft with micrometer for excessive wear and compare with manufacturer's specifications.

d. Clean shaft internally to keep sludge from plugging oil holes.

e. Assemble rocker arms and shaft.

16. Install rocker arm assembly on head.

    a. Fit all rocker arm balls into socket of push rod.

    b. Make sure oil feed stud on line is in the proper place.

    c. Back up adjusting screws.

    d. Tighten rocker arm assembly to head.

17. Adjust valves.

    They should always be adjusted cold before starting engine.

18. Install valve cover.

    Coat valve cover with sealer and stick gasket to it. Do not coat the other side of the cover gasket.

19. Overhaul and install distributor (gasoline tractor only).

    a. Remove distributor cap.

        1) Check for cracks, corrosion on points, and other signs of wear.
        2) Remove rotor and inspect.

    b. Remove points.

        Check conditions of points.

    c. Remove condensor.

        Test condensor on tester.

    d. Remove point plate.

    e. Check spark advance weights for sticking.

    f. Check spark advance spring tension.

    g. Check distributor shaft and bushing for excessive wear.

    h. Assemble in reverse order.

i. Lubricate advance weights with number 10-weight oil.

j. Install new points and condensor.

k. Adjust the distributor to the manufacturer's specifications on high cam and lubricate cam with distributor cam grease.

l. Install rotor and cap.

20. Install and time distributor. See "Tractor Tune-Up and Maintenance" module for procedure.

21. Install spark plug wires.

a. Check spark plug wires for cracks and bad insulation.

b. Check terminals, making certain that they fit tight in the distributor cap and on the spark plug.

c. Check the spark plug firing order.

1) Remove the spark plug in the number one cylinder.
2) Rotate crankshaft until the number one piston is almost at the top of the compression stroke.
3) Insert spark plug.
4) Install the wire on the spark plug and in the distributor cap wire plug opening which the rotor in the distributor points to.
5) Install the remaining wires in rotation, running them to the plugs according to the firing order.
6) The cylinders are numbered starting with the first cylinder, which is the closest to the radiator, and counting back.

22. Install injector pump (diesel tractor only).

a. Rotate engine to bring the number one cylinder to the top of its compression stroke.

b. Line up crankshaft pulley on flywheel timing marks.

c. Turn the injector pump to proper timing mark and slide it into the block, meshing the gear on the pump with the gears on the crankshaft.

d. Recheck alignment of all markings.

e. Reassemble all parts in the reverse order.

23. Overhaul and install water pump.

a. Remove fan from the pump.

b. Remove fan hub and pulley with a pulley puller and mark the position of the hub on the shaft.

c. Remove rear pump cover.

d. Remove pump impeller from shaft.

e. Remove seal assembly.

f. Remove snap ring and then shaft and bearing from the pump housing.

g. Clean housing with a scraper and sand paper and blow clean with compressed air.

h. Install new water pump kit.

1) Using soft hammer, tap shaft and bearing into housing, and install snap ring.
2) Install new seal in the pump impeller.
3) Press impeller into place on the shaft. Do not tap on the shaft or seal, as it will break the seal.
4) Press fan nub onto shaft in its original position.
5) Install gasket and rear pump cover.
6) Install a new pump gasket.
7) Install pump on engine.

24. Overhaul and install generator.

a. Overhaul generator.

1) Remove and inspect generator cover.
2) Remove terminal wire from armature brush holder.
3) Remove wire from field to armature brush.
4) Remove long bolts from the commutator end-frame, and remove frame and generator brushes.

5) Remove field housing from pulley end-frame. Remove the pulley by removing the attachment nut and pressing the shaft from the pulley.
6) Remove pulley key and top armature shaft from the bearing.
7) Remove bearing from frame and check, clean, and repack it with grease. Clean generator parts in cleaning solution, wash with water, and blow dry with air under low pressure.
8) Check commutator end-frame bushing and armature shaft for excessive wear. Replace bushing, if necessary.
9) Check armature.

   a) Grawler test
   b) Induction test
   c) Light short test

10) Check field coil.

   a) Light continuity test
   b) Light short test

11) Turn commutator on metal turning lathe and undercut mica. Smooth commutator with fine sandpaper.
12) Install new brushes and make certain they fit properly against the commutator.
13) Assemble the generator, reversing the disassembly order outlined above.

b. Install generator on engine.

   1) Install new fan belt and tighten. (Refer to "Tractor Tune-up and Maintenance" module, p.10.)
   2) Polarize generator. (Refer to "Tractor Tune-up and Maintenance" module, p.10.)

25. Overhaul and install starter.

a. Remove starter and inspect its parts.

b. Remove screws holding field wires to brush holders.

c. Remove end-frame bolts and frame. Center punch housing for use in aligning the frame and housing.

d. Remove bolts from drive-end frame and remove the frame.

e. Remove armature from field housing.

f. Remove and inspect drive mechanism.

1) Check for broken spring.
2) Check for sheared drive bolt.
3) Check for untrue gear teeth.
4) Check for sticking screw mechanism caused by heavy grease, oil, or rust.
5) Clean parts, install new parts, as needed, and lubricate with 10-weight or a lighter oil.

g. Check field coils.

1) Use light test for continuity.
2) Use light test for detecting a short.

h. Check armature.

1) Use grawler test.
2) Use light test for shorts.
3) Use grawler test for induction.
4) Turn commutator on metal lathe. Do not undercut the mica on a starter commutator.

i. Check end-frame bushing for excessive wear, and replace if necessary.

j. Check armature lamintation for wear, which would suggest worn bushings.

k. Seat new bushings on commutator.

l. Reassemble starter, and install on the engine.

26. Install water manifold.

a. Check thermostat.

1) Place the thermostat in a pan of water.
2) Heat the water with a torch.
3) Note the temperature of the water when the thermostat opens.
4) Check this temperature reading with the manufacturer's specifications for temperature at which the thermostat should open. If the thermostat does not open within manufacturer's specifications, replace it with a new one.

b. Install thermostat in the head, with coil toward the block.

c. Install water manifold gasket and water manifold on the head.

27. Install intake and exhaust manifold.

a. Scrape and sand head and manifold gasket surfaces.

b. Install gasket on head.

c. Install manifold.

d. Torque bolts uniformly to meet manufacturer's specifications.

27A. On diesel engines the manifold heater must be cleaned and adjusted at this stage in the overhaul procedure.

a. Remove heater from manifold.

b. Check for burnt insulator material that may be shorting heater element.

c. Check insulated bolts.

d. Check element for burnt spots.

e. Check element for proper ground.

f. Reassemble element and install in the manifold.

g. Test the heater element.

1) Connect manifold to the positive post of a 1250 battery.
2) Connect insulated terminal to negative post. Wait 60 seconds and check the element. It should be red hot.

28. Overhaul and install fuel injectors (diesel only) .

a. Remove injectors and attach to pump injector tester.

1) Note pressure build-up until the injector injects fuel.
2) Keep hands away from the injector nozzle, as the fuel is under high enough pressure to penetrate the skin.

3) Watch spray pattern.
4) Check injector to see if it will hold pressure to within 300 lbs. of pop-off without leaking at tip.

b. Clean injector.

1) The injector should be cleaned and reset according to the procedures outlined by the manufacturer.
2) Cleanliness is of utmost importance here because all parts are built with close tolerance.

c. Install injector after overhauling the engine.

d. Using a piece of dowl stick wrapped in a soft cloth, wipe the injector hole clean.

e. Place a new copper gasket on the injector and install the injector in the head.

f. Tighten the injector hold-down nuts uniformly, according to manufacturer's specifications.

g. Install fuel lines.

Note: The following procedure should be carried out after the fuel filters are cleaned.

h. Bleed injector.

1) Loosen all injector lines at the injector and set the throttle to start.
2) Crank engine until fuel leaks from lines.
3) Close all lines and start engine.
4) Loosening one line at a time, let all air out of the line.

29. Overhaul and install governor (gasoline tractor only).

a. Clean governor.

b. Disassemble unit and check for the following:

1) Worn linkage
2) Worn weight pins
3) Worn and flat spots on weight balls
4) Worn bearing, bushing, and shaft
5) Worn and broken thrust bearing
6) Tension on governor spring

c. Reassemble entire unit.

d. Install new gasket, using aviation sealer to seal gasket to housing, and install the governor on the engine.

30. Overhaul and install carburetor.

a. Disassemble entire carburetor.

1) Remove screw around the float, and split carburetor.
2) Remove float by slipping pin out of bracket.

a) Check float for dents.
b) Shake float to see if there is fuel inside it.

3) Remove float needle valve assembly, seat, and seat gasket.

a) When installing the seat, make sure the new seat gasket is in place.
b) Needle, seat, and gasket should always be replaced for good fuel regulation.

4) Remove all jets.
5) Soak all parts in a carburetor cleaning solution for one hour.
6) Wash with hot water, and blow dry with compressed air.

b. Assemble carburetor.

1) Install carburetor overhaul kit.
2) Install jets in the lower and upper carburetor housing.
3) Install float seat in upper carburetor housing.
4) Install float and pin. Adjust float according to manufacturer's specifications.
5) Reassemble remaining parts.
6) Check choke butterfly to see that the anti-flooding valve is operating properly.
7) Preset all outside adjustments to manufacturer's specifications.

c. Install new carburetor flange gasket.

d. Install carburetor on the engine.

e. Start engine and set the carburetor for maximum R. P. M.'s by adjusting the governor spring according to the manufacturer's specifications.

31. Set spark plug gap and install spark plugs.

a. Measure the spark gap with a feeler gauge. Compare this gap with the manufacturer's specifications and adjust with a bending tool.

b. Attach spark plug wires.

32. Install oil filter.

a. Install gasket on oil filter bracket, using aviation sealer and bolt filter to block.

b. Soak oil filter element in either number 10- or number 20-weight oil and install filter in bracket.

33. Remove, clean, and install fuel filters (Diesel tractors only).

a. Remove primary fuel filter element. This is the filter closest to the tank.

1) Turn fuel off at tank.
2) Remove cap screw from top of bracket.
3) Remove fuel filter cup.
4) Remove element from filter cup.
5) Wash filter cup in diesel fuel.
6) Install new elements in filter cup.
7) Fill filter cup with clean diesel fuel.
8) Install filter cup in bracket, and install on the engine.

b. Bleed filter.

1) Loosen bleed screw on the top of the filter. Turn fuel on and open bleed screw until air bubbles cease.
2) Tighten bleed screw.

c. Clean secondary filter.

1) Turn fuel valve off.
2) Disconnect fuel lines.
3) Remove filter from bracket.
4) Remove fuel line fittings from old filter.
5) Discard old filter.
6) Reinstall fuel line fittings in new filter, using aviation sealer on fittings.
7) Reassemble secondary filter.
8) Turn fuel valve on.
9) Loosen bleed screw in the top of the filter and let the air out of the filter cup.

Suggested Teaching-Learning Activities

1. Identify and demonstrate special tool usage before the class.

2. Using charts, overhead transparencies, and other instructional materials, discuss with the class each step in the overhaul procedure.

3. Following the engine repair procedure outlined in this module, have students repair the engines on their respective tractors.

Suggested Instructional Materials and References

Instructional materials

1. Special tools used in repairing tractor engines

2. Charts, overhead transparencies, and other instructional materials pertaining to the content

3. A tractor for each two students

References

1. Farm Tractor Guide.

2. For Better Diesel Engine Overhaul.

3. For Better Gasoline Engine Overhaul

4. Implement and Tractor Service Manual

5. Manufacturer's service manuals.

6. Perfect Circle Service Manual.

7. Piston Rings, Pistons, and Cylinders.

Suggested Occupational Experience

Have students overhaul a tractor engine at a local agricultural machinery dealership under the supervision of the head mechanic. Have them parallel their work on the engine at the agricultural machinery dealership with their classroom study and repair procedures.

IV. To repair a tractor clutch

Teacher Preparation

Subject Matter Content

1. Check the clutch plate.

   a. Inspect lining for wear.

   b. Check plate and hub for cracks.

   c. Inspect shock springs for breakage.

   d. Inspect spline in hub for wear.

2. Check pressure plate.

   a. Check plate for cracks.

   b. Inspect for burnt spots.

   c. Check for broken springs.

   d. Check fingers for wear.

   e. Disassemble pressure plate and check the tension on all springs. Following the manufacturer's specifications, make the above checks and repairs, and reassemble.

   f. Install new pilot bearing on bushing on crankshaft. Grease inside of bushing with a small amount of wheel bearing grease after installing in the crankshaft.

3. Install flywheel on the crankshaft and torque bolts to manufacturer's specifications.

4. Install clutch.

   a. Place clutch disk against the flywheel.

   b. Insert clutch aligning tool in clutch and pilot bearing.

   c. Place pressure plate against the flywheel and install special shoulder capscrew.

   d. Torque capscrews to manufacturer's specifications.

   e. Remove aligning tool.

   f. Check fingers to be certain that they are the right distance from the clutch hub. Follow the manufacturer's specifications to adjust the clutch fingers.

5. Install new throw-out bearing on transmission main shaft tube.

   a. Lubricate tube with small amount of grease.

   b. Check throw-out bearing return spring for breaks and twists.

Suggested Teaching-Learning Activities

1. Identify and demonstrate special clutch tool usage before the class.

2. Using charts, overhead transparencies, and other instructional materials, discuss with the class each step in the repair procedure outlined in the content.

3. Following the clutch repair procedure in this module, have students repair the clutches of their assigned tractors.

Suggested Instructional Materials and References

Instructional materials

1. Special tools used in repairing clutch

2. Charts, overhead transparencies, and other instructional materials pertaining to the content

3. A tractor for each two students

References

1. Implement and Tractor Service Manual.

2. Manufacturer's service manuals.

Suggested Occupational Experience

Have students overhaul a tractor clutch at a local agricultural machinery dealership under the supervision of the head mechanic. Have them parallel their work on the clutch there with their classroom study and repair procedures.

V. To repair a tractor transmission

Teacher Preparation

Subject Matter Content

Before beginning any major overhaul of the transmission, study the manufacturer's trouble shooting service guide and attempt to diagnose trouble in the transmission.

Common transmission troubles include:

1. Locking into gear

2. Slipping out of gear

3. Oil transfer from one compartment to another

4. Missing gear teeth

5. Excessive noise caused by loose bearings or excessive end play

For repair, follow these procedures:

1. Remove transmission from the differential.

2. Remove external parts from transmission.

   a. Battery and box

   b. Brake and clutch pedals

c. Steering mechanism

d. Platform

3. Drain out transmission oil.

4. Remove PTO shaft.

a. Remove bolt from PTO bearing cover.

b. Use bar to pry PTO shaft and bearing out of the transmission housing.

c. Inspect PTO bearing and shaft.

1) Remove snap ring from shaft.
2) Using press or puller, remove bearing from shaft.
3) Check PTO seal located in the cover, and replace if necessary.

a) Use punch and hammer to remove seal.
b) Coat inside of new seal with aviation sealer. Using a flat plate, press seal into cover. Coat inside of seal with grease.

4) Check PTO bearing.

a) Wash bearing in cleaning solution and blow dry with compressed air.
b) Lubricate bearing with number 10-weight oil and rotate with hand. If bearing does not have a smooth, quiet roll, replace it.

5) Check PTO shaft.

a) Shaft must be straight.
b) Spline should be in good condition.
c) Seal surface should be smooth.
d) Reassemble PTO.

5. Remove transmission shifting cover.

a. Remove bolts around cover and lift cover off.

b. Check and repair cover.

1) Follow manufacturer's recommended procedure for repairing the transmission cover.

2) Check for excessive wear on shifting forks, rails, and lever, shifter pins, cup and snap ring.

c. Loosen set screws holding rail to fork.

d. Check for worn or weak detent pins and springs, and bent or sprung shifting fork.

6. Remove bolts around rear transmission housing, separating transmission from differential. At this point it may be necessary to remove brakes if they are mounted on the transmission.

7. Remove internal parts of the transmission, following the manufacturer's recommendations found in the index under "Transmission Overhaul."

a. Remove transmission input shaft.

1) Check gear teeth for chips, excessive wear, and pitting.
2) Check ball bearing.

a) Wash the bearing and blow dry with compressed air.
b) Lubricate it with clean oil.
c) Rotate bearing, checking for smoothness of roll and noise.
d) Check bearing for excessive end play.
e) Check all other ball bearings in the transmission in the same manner.

b. Remove and check the output shaft.

1) Inspect the third and fourth shifting collar for excessive teeth radius.
2) Check the sliding gear for excessive teeth wear and radius, chipped or broken teeth, and pits in the teeth.

c. Remove and check the idler gear and shaft.

1) Check idler gear and shaft.

a) Using a micrometer, measure the shaft for excessive wear. Compare findings with the manufacturer's specifications for shaft size.

b) Using the outside micrometer and telescopic gauge, check the wear on the internal bushing of the reverse idler gear.
c) Check the teeth on the idler gear for pitting, chipping or cracking, and excessive radius.

d. Remove countershaft gear assembly..

1) Remove shaft that runs through the housing and countershaft gear assembly.

a) Drive shaft out with a brass rod or punch.
b) Lift assembly out of housing.
c) Check countershaft assembly.

-- Check gears for pitting, chipping, and excessive radius on the teeth.
-- Check countershaft bearing.
-- Check countershaft for excessive wear.

d) Using a micrometer, measure all thrust washers for thickness, and compare these thicknesses with the manufacturer's specifications.

e. Replace all seals.

f. Reassemble transmission. Follow the manufacturer's procedure for assembling the transmission and adjusting all bearings and end play.

g. Install transmission cover.

1) Make sure all forks fit over their respective gears.
2) Tighten bolts.

h. Install all other transmission parts.

i. Fill the transmission with the oil recommended by the manufacturer.

Suggested Teaching-Learning Activities

1. Identify and demonstrate special transmission tool usage before the class.

2. Using charts, overhead transparencies, and other instructional materials, discuss with the class each step in the repair procedure outlined in the content.

3. Following the transmission repair procedure in this module, have students repair the transmissions of their assigned tractors.

Suggested Instructional Materials and References

Instructional materials

1. Special tools used in repairing transmission

2. Charts, overhead transparencies, and other instructional materials pertaining to the content

3. A tractor for every two students

References

1. Implement and Tractor Service Manual.

2. Mechanics Study Guide No. 5 -- Transmission Theory.

3. Manufacturer's service manuals.

Suggested Occupational Experience

Have students overhaul a tractor transmission at a local agricultural machinery dealership under the supervision of the head mechanic. Have them parallel their work there with their classroom study and repair procedures.

VI. To repair tractor brakes

Teacher Preparation

Subject Matter Content

1. Jack the tractor up and remove the rear wheels.
2. Place safety jack under the differential housing.
3. Remove brake drum.
   a. Remove screws holding the drum to the axle hub and remove drum.
   b. Remove the large nut that holds the wheel hub to the axle. Use a wheel puller to remove the hub from the axle.
4. Inspect the brake assembly.
   a. Check brake linings for wear.
   b. Check for oil leakage into brakes.
   c. Check to see if linkage is worn or frozen.
   d. Check the brake drum for scarring. If scarred, it may have to be turned on a metal lathe to be renewed.
   e. Check brake return springs for rusting and breakage.
5. Remove brake shoes and replace linings.
   a. Use a small punch to remove rivets.
   b. Clean shoes and rivet new linings to the shoe with a rivet set or rivet machine.
6. Install a new oil seal if the old seal is leaking oil into the brake assembly.
7. Reassemble brake parts and reinstall the tractor wheels.
8. Adjust the brakes.

9. Follow the manufacturer's recommended procedure for overhauling brakes that are located on the transmission. Use the procedure outlined above for inspecting these brakes.

Suggested Teaching-Learning Activities

1. Identify and demonstrate special brake tool usage before the class.

2. Using charts, overhead transparencies, and other instructional materials, discuss with the class each step in the repair procedure outlined in the content.

3. Following the brake repair procedure in this module, have students repair the brakes on their assigned tractors.

Suggested Instructional Materials and References

Instructional materials

1. Special tools used in repairing brakes

2. Charts, overhead transparencies, and other instructional materials, discuss with the class each step in the repair procedure outlined in the content.

3. A tractor for every two students.

References

1. Implement and Tractor Service Manual .

2. Manufacturer's service manuals.

Suggested Occupational Experience

Have students overhaul a set of tractor brakes at a local agricultural machinery dealership under the supervision of the head mechanic. Have them parallel their work there with their classroom study and repair procedures.

VII. To repair and adjust the final drive

Teacher Preparation

Subject Matter Content

1. Jack up the tractor and remove the rear wheels.
2. Place safety jacks under the differential housing.
3. Remove the housing and gears.
   a. Drain the oil from the final drive pans.
   b. Remove final drive pan.
   c. Remove the cap on the inner stub axle.
      1) Remove the bolts holding the cap. Knock the cap out by driving on the stub axle.
      2) Note the number of shims on the cap used to adjust the bearings. Keep these with the cap.
      3) Inspect bearing cup in the cap for wear and pitting.
4. Remove the stub axle.
   a. Remove the snap ring along the side of the gear that holds the gear in position on the stub axle.
   b. Drive axle out of the housing.
   c. Remove roller bearing from the axle with a bearing puller. Pull only on the inner race of the bearing.
5. Remove bowl gear.
6. Remove outside upper axle cap.
   a) Note the number of shims on the cap for adjusting bearings. Keep these with cap.
   b) Pull axle away from the differential.
7. Remove housing.
   a. Remove bolts holding the final drive housing to the differential housing.
   b. Pull the final drive housing away from the differential housing.

8. Check housing, bearings, axle, and gears.

   a. Check housing for cracks.

   b. Check bearings.

      1) Remove bearings.
      2) Wash the bearings and blow dry with compressed air.
      3) Inspect all bearing rollers, noting any pits or burnt spots.
      4) Inspect the inner race on roller bearings by holding bearing up to the light and observing the race as the bearing rotates. Note any pits, chips, or cracks on the rollers.
      5) Check all bearing cups for pits, chipping, color, or excessive groove wear in cups.

   c. Check stub axle.

      1) Check spline or keyway for excessive wear.
      2) Check bearing surface for bearing scars.

   d. Check bowl gear and axle gear for teeth worn to a sharp edge, internal spline wear, and chipped teeth.

9. Install housing on differential.

   a. Install a new gasket.

   b. Install new axle seal in housing and coat the inside of the housing with grease.

10. Install stub axle.

   a. Drive stub axle through bowl gear with new seals installed.

   b. Install snap rings.

   c. Install inside axle cap with shims and coat bearing with grease.

   d. Tighten bolts.

   e. Rotate gear. If bearings are too tight, add more shims. If bearings are too loose, remove shim. There should be a slight drag on the gear rotation.

f. If stub axle has adjustable nut under the cap, adjust in the same manner as the front wheel bearing is adjusted.

11. Install upper axle in housing.

a. Coat bearing with grease.

b. Install upper outside axle cap with shims. Shift transmission into neutral position and rotate bowl gear. Remove shims under cap until the drag slightly increases on bowl gear rotation.

12. Install new oil pan gasket.

13. Install oil pan.

14. Fill final drive pan with the kind of oil recommended by the manufacturer.

Suggested Teaching-Learning Activities

1. Identify and demonstrate special final drive repair tool usage before the class.

2. Using charts, overhead transparencies, and other instructional materials, discuss with the class each step in the repair procedure outlined in the content.

3. Following the final drive repair procedure in this module, have students repair the brakes on their assigned tractors.

Suggested Instructional Materials and References

Instructional materials

1. Special tools used in repairing final drives

2. Charts, overhead transparencies, and other instructional materials pertaining to the content

3. A tractor for every two students

References

1. Implement and Tractor Service Manual.

2. Manufacturer's service manuals.

Suggested Occupational Experience

Have students overhaul the final drive on a tractor at a local agricultural machinery dealership under the supervision of the head mechanic. Have them parallel their work there with their classroom study and repair procedures.

VIII. To repair and adjust the differential

Teacher Preparation

Subject Matter Content

1. Remove external parts.
   a. Jack tractor up and remove rear wheels.
   b. Place safety jacks under the transmission housing.
   c. Drain oil from the differential.
   d. Remove rear fenders.
   e. Remove tractor seat.
2. Split differential.
   a. Remove axle.
      1) Remove brake drums.
      2) Remove bolts around the back plate.
      3) Remove axle by tapping on the axle flange.
   b. Remove axle.
      1) Remove upper outside axle bearing cap.
         a) Remove bolts around cap.
         b) Pry cap out of housing.
         c) Pull axle out of differential.
   c. Remove bolts around housing of differential and split differential into halves.

3. Remove ring gear carrier.

   a. Remove cover on rear of differential housing.

   b. Mark caps that hold the ring gear carrier in the housing and remove bolts.

   c. Tap caps off with a soft mallet hammer and remove the ring gear carrier. Keep matching bearing cups and cones together.

4. Check axle and pinion gears.

   a. Mark carrier halves for alignment.

   b. Remove bolts holding carrier together and split the carrier into halves.

   c. Remove pinion and axle gears from shaft.

   d. Inspect thrust washers for excessive wear, splitting, and breaks.

   e. Inspect gear and shaft for excessive wear on teeth, chipped teeth, pitted teeth, inside gear wear, and crosshaft wear.

   f. Install new thrust washer and assemble carrier.

   g. Torque carrier bolts to the manufacturer's specifications.

5. Remove ring gear from carrier.

   a. If the ring gear is bolted to the carrier, remove nut locks and bolts.

   b. Remove gear from carrier.

   c. If ring gear is riveted to carrier

      1) Use cutting torch to cut off rivet beads.
      2) Cut rivet beads at the ring gear if ring gear is to be discarded, or cut rivets at the carrier if carrier is to be discarded.
      3) Use punch and hammer or press to push rivets out of the carrier.

4) Remove ring gear.
5) When assembling carrier and ring gear, replace rivets with special bolts and nuts and torque to manufacturer's specifications. Be sure to install locks on nuts.

6. Remove tapered roller bearings from carrier.

   a. Use puller or press to remove bearings.

   b. Inspect bearings. Follow the procedure outlined under step 8 in competency VII.

   c. Press bearing on carrier.

7. Remove pinion gear from differential housing.

   a. Remove bolts from pinion retainer cap.

   b. Using a hard wood block 2" x 2" x 2' and a hammer, drive pinion out of housing.

8. Inspect pinion gear and bearing.

   a. Remove large nuts from pinion shaft.

   b. Press double tapered roller bearing from the pinion shaft.

   c. Inspect bearing. Follow procedure outlined in step 7, competency VII.

   d. Inspect pinion gear for chipped or pitted teeth and excessive wear on the teeth.

9. Press bearings on pinion shaft and lubricate with gear oil.

10. Adjust bearings with large nut on pinion shaft.

    a. Adjust to a slight drag.

    b. Install second nut to lock first nut into position.

11. Install pinion in housing.

12. Install ring gear in housing.

    a. Adjust ring carrier bearings.

        1) Tighten bearing adjuster. Push against bearing cups and tighten to get slight drag on bearings.
        2) Adjust ring gear to pinion back lash.

            a) Tighten adjuster on one side and loosen the other side to move the ring gear closer to the pinion. Reversing this procedure moves the ring gear away from the pinion.
            b) Place dial indicator needly on the ring gear teeth and rotate ring gear back and forth without turning pinion. Note the dial reading and compare it with the manufacturer's specifications. Change reading by moving ring gears closer to or farther away from the pinion.
            c) Lock cap.

13. Install new gasket.

14. Reassemble differential, sealing all parts as they are assembled.

Suggested Teaching-Learning Activities

1. Identify and demonstrate special differential repair tool usage before the class.

2. Using charts, overhead transparencies, and other instructional materials, discuss with the class each step in the repair procedure outlined in the content.

3. Following the differential repair procedure in this module, have students repair the differential on their assigned tractors.

Suggested Instructional Materials and References

Instructional materials

1. Special tools for repairing differentials

2. Charts, overhead transparencies, and other instructional materials pertaining to the content

3. A tractor for every two students

References

1. Implement and Tractor Service Manual.

2. Manufacturer's service manuals.

Suggested Occupational Experience

Have students overhaul the differential on a tractor at a local agricultural machinery dealership under the supervision of the head mechanic. Have them parallel their work there with their classroom study and repair procedures.

IX. To repair the power steering units

Teacher Preparation

Subject Matter Content

1. Check and repair power steering unit. Check for the following minor items that hinder proper unit operation:

   a. Oil in reservoir

   b. Bad filter

   c. Loose drive belt

   d. Plugged air vent in resevoir

   e. Collapsed intake hose

   f. Plugged intake hose

2. Check hydraulic pump for maximum pressure.

   a. Remove pressure line from the hydraulic cylinder.

   b. Connect pressure gauge to line.

   c. Start engine and run at a fast idling speed. Turn steering wheel and note the gauge reading. Check manufacturer's specifications for maximum pump pressure. If satisfactory, connect the line to the cylinder again.

d. Remove the line from the opposite end of the cylinder and repeat the test in step c. A low pressure indicates a worn pump or faulty check valve.

3. Install a pump kit. This kit includes gears, bearings, seals, and "O" rings.

4. Check pump if pressure is low.

   a. Remove lines to pump.

   b. Remove bolts holding pump to block and remove pump.

   c. Disassemble pump. If it is a gear pump, check for worn gears, drive gear slippage and shaft due to sheared key or broken gears, worn housing, and too much clearance between gear teeth.

5. If the pump is the vane type, check for:

   a. Vanes for shortness

   b. Scarred and sticking vanes

   c. Worn housing

   d. Worn bearings

6. Remove and inspect check valve.

   a. Remove large plug.

   b. Remove spring and valve.

   c. Check spring tension on spring tester and compare with manufacturer's specifications.

   d. Check valve for groove in the seat.

   e. Check valve for sticking in housing.

7. Reassemble parts.

8. Remove and check hydraulic cylinder.

   a. Disassemble hydraulic cylinder according to the manufacturer's specifications.

      1) Check piston cups for breaks or splits.

2) Check the "O" ring.
3) Check for split piston packing.
4) Check inside of cylinder for scores that cut piston cup or packings.
5) Reassemble parts, installing complete new gaskets and "O" rings.

9. Check control valve.

a. Remove control valve from the tractor.

b. Disassemble valve control.

1) Look for flat or broken "O" rings.
2) Check for scored valve piston and housing.
3) Check for sticking valve.

c. Reassemble and install new "O" rings.

Suggested Teaching-Learning Activities

1. Identify and demonstrate special power-steering repair tools before the class.

2. Using charts, overhead transparencies, and other instructional materials, discuss with the class each step in the repair procedure outlined in the content.

3. Following the power steering procedure in this module, have students repair the power-steering unit on their assigned tractors.

Suggested Instructional Materials and References

Instructional materials

1. Special tools for repairing power steering units.

2. Charts, overhead transparencies, and other instructional materials pertaining to the content.

3. A tractor for every two students

References

1. Implement and Tractor Service Manual.

2. Manufacturer's service manuals.

Suggested Occupational Experience

Have students overhaul the power steering unit on a tractor at a local agricultural machinery dealership under the supervision of the head mechanic. Have them parallel their work there with their classroom study and repair procedures.

X. To prepare and paint the tractor after it has been repaired

Teacher Preparation

Subject Matter Content

A steam cleaner should be used to remove grease, oil, dirt, and foreign materials from the outside surfaces of the tractor. The manufacturer's instructions for use of the steam cleaner and the recommended cleaning solution to use should be carefully followed when using the steam cleaner. Caution should be exercised to avoid letting steam come in contact with hydraulic lines, pressure bases, etc.

1. Remove all parts that would make it difficult to remove the paint from behind them.

2. Before sanding the tractor surface, cover all openings and other parts that are in danger of being damaged by the dust from the sander.

3. Sand the surface of the tractor.

   a. Using a power disk sander, sand all surfaces with #60 or #80 grit sandpaper.

   b. Use #30 grit sandpaper to remove heavy rust. However, if a rust inhibiting primer is used, it isn't necessary to sand down to bright metal.

   c. Wipe or wash off the sanded surfaces.

4. Prime base metal.

   a. Use a fish oil base rust inhibitive primer on soundly rusted metal and zinc chromate primer on clean metal.

   b. Strain primer before placing it in the spray paint gun.

c. Apply primer evenly on all surfaces avoiding build-ups that will cause the primer to run. If runs develop sand them off and reprime.

d. Sand all primed surfaces with #220 sand paper after the primer has dried.

5. Cover all parts that should not be painted or that should be painted a different color with masking tape or masking cream.

6. Move tractor into a suitable dust-free paint room or paint area.

7. Wipe off all surfaces to be painted with enamel thinner. This step will aid in knitting the primer coat and the fresh paint.

8. Mix paint according to the manufacturer's directions on the paint can. If the paint needs to be thinned use the thinner recommended by the manufacturer of the paint.

9. Apply a light first coat of paint to all and let dry.

10. Using a fine sandpaper, roughen up all painted surfaces. Wipe or blow-off all sanded surfaces.

11. Apply the second coat of paint.

12. Following the above procedures, paint all parts that have been removed or are to be painted a different color.

13. When the paint has dried thoroughly, install parts that were removed earlier.

14. If runs or sags occur in the paint, sand them off, re-prime the sanded area, and repaint.

15. After the paint has thoroughly dried, install duals. Follow the instructions on the duals when installing on the tractor.

16. If problems develop in applying the paint caused by the spraying outfit, consult the operator's manual to correct these problems.

17. After the tractor has been painted, clean the paint gun in a recommended cleaner and wipe all parts dry.

Suggested Teaching-Learning Activities

Have students prepare their tractors for painting and paint them, following the steps outlined in the subject matter content.

Suggested Occupational Experiences

Have students prepare their tractors for painting and paint them at a local agricultural machinery dealership.

Suggestions for Evaluating Educational Outcomes of the Module

The following criteria should be used to evaluate the educational outcomes of this module:

1. How efficiently the student performs the overhaul tasks in his tractor.
2. The quality of work done by the student
3. The understanding the student has of the nature of the work to be done
4. The ability of the student to use references in carrying out his overhaul tasks
5. The ability of the student to detect malfunctions in the tractor
6. The aggressiveness of the student in carrying out overhaul procedures
7. The cleanliness of the student in overhaul procedures
8. The running efficiency of the overhauled tractor under load, as measured by the dynomometer.

Source of Suggested References

1. Farm Tractor Guide. Pittsburgh: Gulf Oil Corporation, Gulf Building, 1964. No charge.
2. For Better Diesel Engine Overhaul, Form 466M. Hagerstown, Indiana: Perfect Circle Corporation, 1961. No charge.
3. For Better Gasoline Engine Overhaul, Form 1227. Hagerstown, Indiana: Perfect Circle Corporation, 1961. No charge.

4. Implement and Tractor Service Manual. Kansas City, Missouri: Implement and Tractor Publications, Inc., 1014 Wyandotte St., $54.00.

5. Mechanics Study Guide -- Transmission Theory. Racine, Wisconsin: Industrial Service Department, J. I. Case Company.

6. Perfect Circle Service Manual. Hagerstown, Indiana: Perfect Circle Corporation, 1961. No charge.

7. Piston Rings, Pistons, and Cylinders, Form 2013. Hagerstown, Indiana: Perfect Circle Corporation, 1963. No charge.

8. Manufacturer's service manuals available through the major line agricultural machinery dealers and manufacturers.

THE CENTER FOR RESEARCH AND LEADERSHIP DEVELOPMENT
IN VOCATIONAL AND TECHNICAL EDUCATION
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INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name_____

2. Name of school_____State_____

3. Course outline used: _____Agriculture Supply--Sales and Service Occupations
   _____Ornamental Horticulture--Service Occupations
   _____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report_____

5. To what group (age and/or class description) was this material presented?____
   _____

6. How many students:
   a) Were enrolled in class (total) _____
   b) Participated in studying this module _____
   c) Participated in a related occupational work experience program while you taught this module _____

7. Actual time spent teaching module:

		Recommended time if you were to teach the module again:
_____hours	Classroom Instruction	_____hours
_____hours	Laboratory Experience	_____hours
_____hours	Occupational Experience (Average time for each student participating)	_____hours
_____hours	Total time	_____hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (✓) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

	VERY APPROPRIATE	NOT APPROPRIATE
8. The suggested time allotments given with this module were:		
9. The suggestions for introducing this module were:		
10. The suggested competencies to be developed were:		
11. For your particular class situation, the level of subject matter content was:		
12. The Suggested Teaching-Learning Activities were:		
13. The Suggested Instructional Materials and References were:		
14. The Suggested Occupational Experiences were:		

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes_____No_____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes_____No_____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

_____ _____
(Date) (Instructor's Signature)

_____
(School Address)